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SOME PLANT SOURCES OF VITAMINS B AND C[1]

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In the problem of food selection, instinct is considered by many persons to be a fairly safe guide. Therefore it is often assumed that the question of vitamin deficiency in the diet needs no special consideration. This, however, is not invariably the case. In the Philippines, where fruits and vegetables abound all the year round, deficiency diseases have occurred and are occurring among the Filipinos as well as among the people living in the temperate zones. That the people who can obtain the foods which are generally considered as excellent sources of vitamins should be subject to deficiency diseases may be due to one or both of the following reasons: They are either eating more and more of artificially treated foods or are not eating the right kind. So far no systematic investigation of the vitamin content of Philippine food materials has been made, except that of Brill and Alincastre on "the possible maximum vitamin content of some Philippine vegetables" (3). In the light of our newer knowledge concerning these mysterious substances, the above work appears of no value. Therefore in a series of studies of the nutrition of the Filipinos it became highly desirable that vitamin tests be made on the fruits and vegetables which are being or may be eaten by them.

Several vegetables and fruits have already been tested for vitamin content by different investigators (27), (28), (7), (34), (9), (16), (21), (30), (31), (32), (33), (17), (18), (26), (24), (11), (4), (8), (20), (35). A thorough review of the subject shows, however, that there are still many uninvestigated, which are commonly eaten. The present work is intended as a beginning of a series of tests which will be undertaken soon. It is regretted that the distance from the Philippines has made

[1] The data in this paper are taken from the dissertation presented by the writer for the degree of Doctor of Philosophy, Yale University, 1922.

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the selection of materials limited to what could be purchased here in the States and what were furnished by Doctor Kellogg of the Battle Creek Sanatorium, the United Fruit Co., and Mr. Ames, Director of the Botanic Garden of Harvard University in Cuba, to whom I desire to express my hearty appreciation. The present tests became dependent on the supply of materials available.

I. TEST FOR VITAMIN B

Method. In order to obtain a comparative estimate of the vitamin content of the materials under investigation a plan similar to the one used by Osborne and Mendel (32) has been adopted. The fruits and vegetables were dried in an air current at less than 85°C. The dried materials were ground finely and then made into pills of 1 gram, ½ gram, or less, according to the need of the experiments. Glucose syrup was used as adhesive.

Osborne and Mendel (31) have prepared a diet for albino rats which has been shown to be complete in every respect except that it lacks vitamin B. This mixture was slightly modified in percentage composition as follows:

Casein	18
Salt mixture[3]	4
Starch	50
Butter fat	9
Lard	19

On this food the rats slowly lose appetite and after a time decline in weight. Then if the diet is not changed or improved by the addition of substances containing vitamin B, death ensues. In most cases the animals promptly improve in appetite when vitamin B is given. But when the source of vitamin is too bulky so that it prevents the ingestion of sufficient of the standard food, the *total* intake of all essentials may become inadequate. The ability to cause the recovery of rats which have been declining in weight on a diet which is known to be complete in every respect except that it lacks vitamin B, has been taken as a proof that the material in question contains the latter.

The feeding technique was essentially like that commonly employed in this laboratory and described by Ferry (12). Protocols of body weights and food intakes are given in tables, and some of the data

[3] The salt mixture used is that described by Osborne and Mendel, Journ. Biol. Chem., 1917, xxxii, 317.

are also presented in graphic forms in charts. (Tables 1 to 10 and charts 1 to 12.)

TABLE 1

Mongo; body weight and weekly intake of standard diet

FEEDING PERIOD	ONE GRAM SUPPLEMENT							
	Rat 3 ♂		Rat 10 ♀		Rat 9 ♀		Rat 7 ♀	
	Body weight	Diet	Body weight	Diet	Body weight	Diet	Body weight	Diet
weeks	*grams*	*grams*	*grams*	*grams*	*grams*	*grams*	*grams*	*grams*
	150							
	168		66					
	178		83		64		70	
	194		95		94		93	
1	174	?	94	33	94	43	99	46
2	164	?	90	34	97	30	92	29
3	152x	?	85	16	90	20	82	20
4	166	46	75	16	84	16	81	16
5	178	44	64x	?	80x	12	76	16
6	190	46	85	29	98	32	76x	12
7	210	53	102	36	108	36	97	36
8	220		104	36	107	32	115	45
9			117	46	115	38	122	46
10			126	40			132	44

FEEDING PERIOD	ONE-HALF GRAM SUPPLEMENT					
	Rat 3 ♂		Rat 11 ♀		Rat 9 ♀	
	Body weight	Diet	Body weight	Diet	Body weight	Diet
weeks	*grams*	*grams*	*grams*	*grams*	*grams*	*grams*
	220					
	218		166		115	
1	202	?	153	34	122	40
2	195	?	150	29	123	40
3	184x	?	140	25	117	27
4	192	45	130x	23	100x	?
5	198	50	143	34	118	36
6	198	43	152	37	120	36
7	196y	54	154	52	132	40
8	206	56	154y	42	136	37
9	231	55	172	50		

DISCUSSIONS OF THE MATERIALS USED AND THE FEEDING EXPERIMENTS. MONGO: (*Phaseolus mongo L.*). This bean contains about

20 per cent protein (N × 6.25) (2). It is extensively used by the Filipinos and is practically the only food of the people afflicted with

TABLE 2

Togi; body weight and weekly intake of standard diet

FEEDING PERIOD	ONE GRAM SUPPLEMENT					
	Rat 1 ♀		Rat 8 ♂		Rat 2 ♀	
	Body weight	Diet	Body weight	Diet	Body weight	Diet
weeks	*grams*	*grams*	*grams*	*grams*	*grams*	*grams*
	136				134	
	144		67		144	
	150		95		154	
1	140	?	112	41	138	?
2	116x	?	103	29	102x	?
3	136	43	98x	?	136	56
4	150	49	118	35	160	62
5	152	52	135	31	162	50
6	153	36	149	42	174	46
7	156	40	164	35	180	
8	162	47	175	36		
	ONE-HALF GRAM SUPPLEMENT					
	Rat 11 ♀		Rat 13 ♂		Rat 6 ♀	
	130					
	144				74	
	156		165		98	
1	156	33	162	60	105	40
2	154	35	159	46	100	34
3	141	16	150	26	92	24
4	130	16	140	17	92	28
5	118x	15	128	?	94	27
6	130	44	122x	?	98	23
7	146	50	132	50	92	21
8	153	36	144	39	90	23
9	159	39	153	42	82x	24
10	166	38	165	46	98	41
11			177	47	120	46
12					135	39
13					148	48

wet beriberi who at the same time cannot buy milk The mongo used was bought from a Chinese grocery store at New Haven. The bean

TABLE 3

Sweet potato leaves; body weight and weekly intake of standard diet

FEEDING PERIOD	ONE GRAM SUPPLEMENT				ONE-HALF GRAM SUPPLEMENT			
	Rat 1 ♀		Rat 2 ♀		Rat 3 ♂		Rat 4 ♂	
	Body weight	Diet	Body weight	Diet	Body weight	Diet	Body weight	Diet
weeks	*grams*	*grams*	*grams*	*grams*	*grams*	*grams*	*grams*	*grams*
	132		126		198		186	
1	128	43	124	40	190	47	181	43
2	128	37	113	24	184	49	170	39
3	113x	15	100x	15	168	41	159	29
4	124	35	115	27	148x	15	138x	16
5	136	49	134	44	150	29	128	21
6	144	49	144	48	168	52	121	18
7	150	44	154	39	178	44	132	36
8					194	49	140	29
9							143z	37
10							159	52
11							153y	48
12							164	50
13							180	45
14							195	49

z = 0.2 gram yeast was given as daily supplement.

TABLE 4

Bilimbi; body weight and weekly intake of standard diet

FEEDING PERIOD	ONE GRAM SUPPLEMENT			
	Rat 26 ♀		Rat 6 ♀	
	Body weight	Diet	Body weight	Diet
weeks	*grams*	*grams*	*grams*	*grams*
	127		140	
1	130	37	136	31
2	132	38	130	27
3	137	41	124	27
4	130	33	122	?
5	116x	28	120x	?
6	110y	11	115d	?
7	137	52	132	41
8	160	67		

d = given one gram duhat daily instead of bilimbi.

TABLE 5

Duhat; body weight and weekly intake of standard diet

FEEDING PERIOD	ONE GRAM SUPPLEMENT			
	Rat 18 ♂		Rat 6 ♀	
	Body weight	Diet	Body weight	Diet
weeks	*grams*	*grams*	*grams*	*grams*
	150		140	
1	160	54	136	31
2	154	46	130	27
3	154	36	124	27
4	153	?	122	?
5	143	?	120	?
6	142	?	115x	?
7	140	?	132	41
8	138	?		
9	128x	?		
10	144	35		
11	152	55		
12	160	46		
13	176	50		

The supply of duhat was exhausted

TABLE 6

Okra; body weight and weekly intake of standard diet

FEEDING PERIOD	ONE GRAM SUPPLEMENT		ONE-HALF GRAM SUPPLEMENT			
	Rat 1 ♀		Rat 13 ♂		Rat 4 ♂	
	Body weight	Diet	Body weight	Diet	Body weight	Diet
weeks	*grams*	*grams*	*grams*	*grams*	*grams*	*grams*
	162		177			
	159		159		195	
1	159	44	148	38	192	47
2	138	?	129x	?	178	45
3	118x	?	146	45	178	62
4	142	53	156	48	166	32
5	160	60	167	45	152x	29
6	164	43	174	50	170	47
7	179	47	180	52	180	40
8					178	48
9					186	51
10					204	59

TABLE 7

Artichokes; body weight and weekly intake of standard diet

FEEDING PERIOD	ONE GRAM SUPPLEMENT					
	Rat 23 ♂		Rat 24 ♂		Rat 22 ♂	
	Body weight	Diet	Body weight	Diet	Body weight	Diet
weeks	*grams*	*grams*	*grams*	*grams*	*grams*	*grams*
	175		226		205	
	180		224		198	
1	186	62	234	51	184	36
2	191	48	220	39	168x	22
3	182	44	212	28	181	45
4	169	?	195	31	204	62
5	161	36	184x	22	218	64
6	155x	23	197	35	222	
7	177	50	201	36		
8	188	46	204	45		
9	190	54	218	50		
10	190y	48	210y	32		
11	208	59	240	56		

FEEDING PERIOD	ONE-HALF GRAM SUPPLEMENT			
	Rat 15 ♂		Rat 25 ♂	
	Body weight	Diet	Body weight	Diet
weeks	*grams*	*grams*	*grams*	*grams*
	212			
	212		218	
1	196	34	220	70
2	178x	19	224	49
3	181	?	218	38
4	191	44	209	34
5	196	30	195	36
6	196y	?	190	35
7	220	60	178x	31
8			185	50
9			185	48
10			192	40
11			190y	?
12			204	53
13			220	57
14			224	

TABLE 8

Avocado; body weight and weekly intake of standard diet

FEEDING PERIOD	ONE GRAM SUPPLEMENT				ONE-HALF GRAM SUPPLEMENT			
	Rat 7 ♀		Rat 21 ♂		Rat 17 ♂		Rat 20 ♂	
	Body weight	Diet	Body weight	Diet	Body weight	Diet	Body weight	Diet
weeks	*grams*	*grams*	*grams*	*grams*	*grams*	*grams*	*grams*	*grams*
	141		180		148		148	
	132		187		156		154	
1	121	26	194	49	160	56	153	45
2	112x	?	192	48	158	48	147	42
3	139	44	178	36	147	26	138	26
4	150	56	155x	18	130x	?	120x	20
5	150	42	207	69	160	53	141	42
6	158	54	240	71	178	59	152	49
7			240	61	192	54	167	50
8			244	58	200	48	172	47

FEEDING PERIOD	ONE-TENTH AND FOUR-TENTH GRAM SUPPLEMENTS			
	Rat 16 ♂		Rat 19 ♂	
	Body weight	Diet	Body weight	Diet
weeks	*grams*	*grams*	*grams*	*grams*
	202		156	
			154	
1	172	26	160	51
2	168	31	154	37
3	178	44	154	33
4	176	39	148	27
5	178	41	142	28
6	170x	45	134x	25
7	162	38	130	30
8	154xx	28	128xx	37
9	165	34	142	36
10	160	48	153	43
11	170	47	160	58
12	162y	35	160y	51
13	176	64	184	59
14	200	72		
15	206			

x = 0.1 gram.
xx = 0.4 gram.

was soaked in water for a day, then cooked as is done for culinary use. The mashed mongo including the water in which it was boiled, was then dried, powdered and finally made into pills. Rats declining in weight easily recovered their original weight under a daily supplement of 1 gram to the standard ration free from vitamin B. With ½ gram, one animal recovered its original weight, while two did not in about the same length of time thus indicating that the latter dose is about the minimum for this species.

TOGI: This is the name given to the sprouted mongo. The bean was first soaked in water for 24 hours, then allowed to sprout in the dark for 2 days, cooked, dried including the water used for boiling, and

TABLE 9

Banana flower bud; body weight and weekly intake of standard diet

FEEDING PERIOD	ONE GRAM SUPPLEMENT					
	Rat 27 ♀		Rat 28 ♀		Rat 10 ♀	
	Body weight	Diet	Body weight	Diet	Body weight	Diet
weeks	*grams*	*grams*	*grams*	*grams*	*grams*	*grams*
	150		184		126	
1	155	40	186	51	125	32
2	152	38	185	43	122	30
3	154	45	188	51	119	28
4	147	30	178	34	115	27
5	132x	?	161x	26	110	28
6	115y	?	145y	27	110	28
7	145	60	178	67	108	26
8	162	55	196	62	96x	20
					Died	

powdered. Both 1 gram and ½ gram daily supplements caused quick recovery in weight of rats which had been declining on a diet deficient in vitamin B. One-half gram of the togi was more potent than ½ gram of the mongo. This indicates that the vitamin B in the mongo is increased in sprouting; a fact contrary to the finding of Grijns (cited by Chick and Hume (6)) that the anti-beriberi vitamin is lessened in amount as germination takes place. Togi then has three advantages over mongo: greater digestibility (1) and greater content of vitamins B and C (see later).

SWEET POTATO LEAVES: (*Batatas batatas*). The leaves and young shoots of sweet potato are used as vegetables in making stews and simi-

lar dishes. The material for study was obtained dry. One gram daily supplement fed to rats which had been declining in weight on a diet deficient in vitamin B caused immediate recovery. In about the same length of time $\frac{1}{2}$ gram caused only partial recovery. The latter dosage is not as efficient as $\frac{4}{10}$ gram of dried brewery yeast.[4]

TABLE 10

Bamboo shoots; body weight and weekly intake of standard diet

FEEDING PERIOD	ONE GRAM SUPPLEMENT					
	Rat 12 ♂		Rat 15 ♂		Rat 16 ♂	
	Body weight	Diet	Body weight	Diet	Body weight	Diet
weeks	*grams*	*grams*	*grams*	*grams*	*grams*	*grams*
	175					
	203		164		202	
1	205	64	178	63	201	74
2	204	65	185	55	202	67
3	188	42	176	37	176	26
4	176	19	158x	?	158x	13
5	157x	10	162	26	168	44
6	172	36	163	41	173	48
7	191	31	172	38	180	41
8	195	46	182	38	172	26
9	196d	43	188xx	42	168xx	31
10	192	42	190	41	178	44
11	170xx	22	196	38	176	39
12	184	44	208	64	178	41
13	198	63	212	54	170y	45
14	198	55				
15	198y	49				
16	210	60				
17	222	68			206	

x = 1 gram.
xx = 2 grams.
d = diet only again.

BILIMBI: (*Averrhoa carambola L.*). Only a small sample in dry condition was obtained, so only the one gram supplement could be tested. After 7 days of 1 gram daily supplement, no improvement in the weight of the animals was found. The intake of basal diet did not

[4] The dried brewery yeast used was kindly furnished by Osborne and Mendel from their stock.

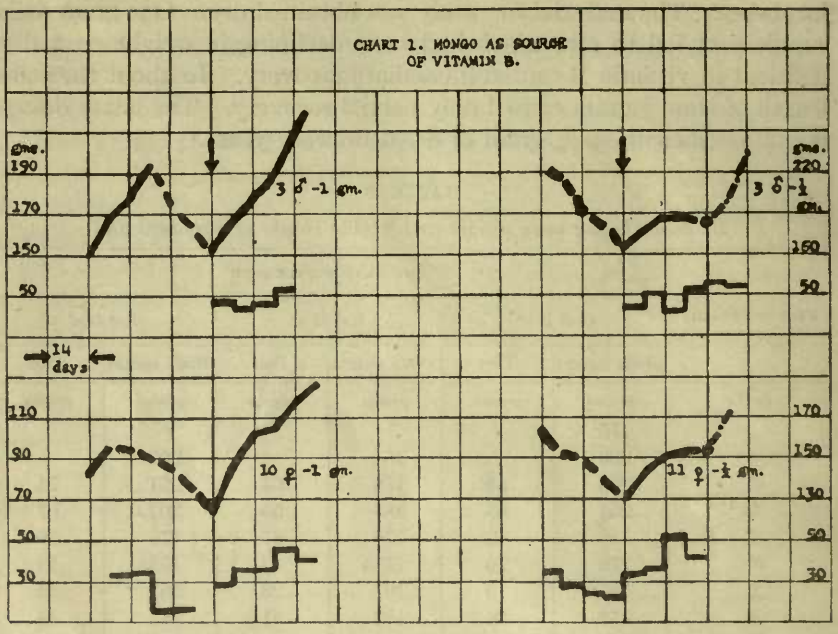


CHART 1. MONGO AS SOURCE OF VITAMIN B.
gms.
190
170
150
50
3 ♂ -1 gm.
3 ♂ -½ gm.
14 days
110
90
70
50
30
10 ♀ -1 gm.
11 ♀ -½ gm.
170
150
130
50
30

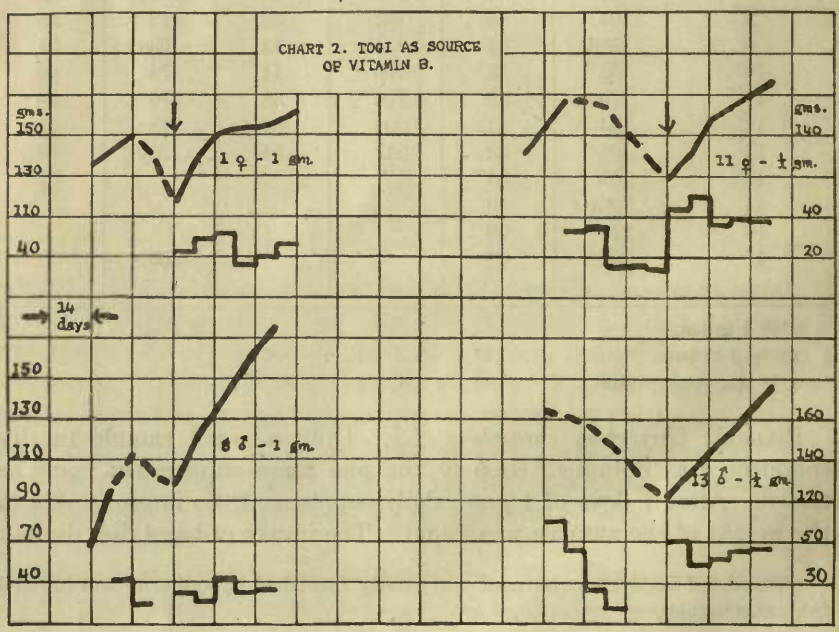


CHART 2. TOGI AS SOURCE OF VITAMIN B.
gms.
150
130
110
40
1 ♀ - 1 gm.
11 ♀ - ½ gm.
140
40
20
14 days
150
130
110
90
70
40
8 ♂ - 1 gm.
13 ♂ - ½ gm.
160
140
120
50
30

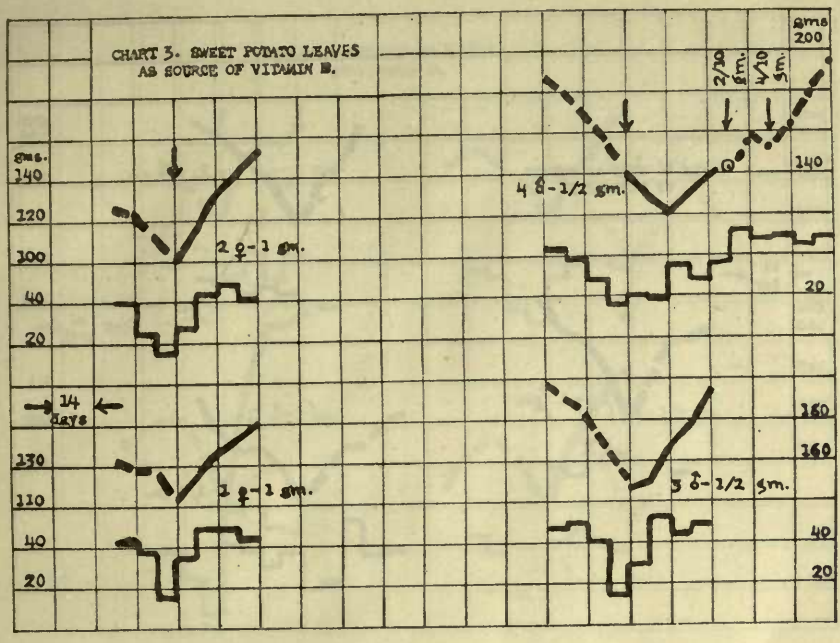


CHART 3. SWEET POTATO LEAVES AS SOURCE OF VITAMIN B.
gms.
140
120
100
40
20
2 ♀-1 gm.
14 days
130
110
40
20
3 ♀-1 gm.
gms
200
2/20 gm.
4/10 gm.
140
4 ♂-1/2 gm.
20
160
160
3 ♂-1/2 gm.
40
20

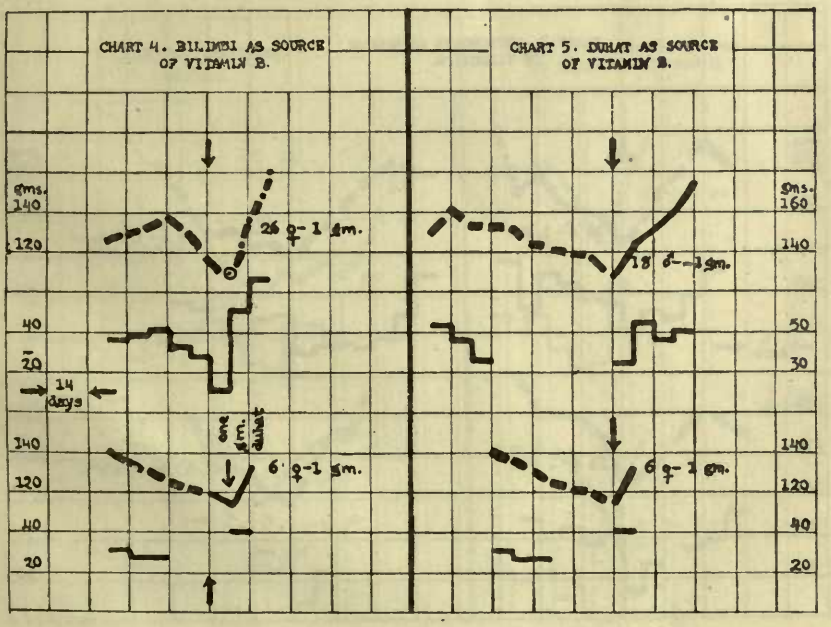


CHART 4. BILIMBI AS SOURCE OF VITAMIN B.
gms.
140
120
26 ♀-1 gm.
40
20
14 days
Bilimbi
140
120
6 ♀-1 gm.
40
20
CHART 5. DUHAT AS SOURCE OF VITAMIN B.
gms.
160
140
18 ♂-1 gm.
50
30
140
120
6 ♀-1 gm.
40
20

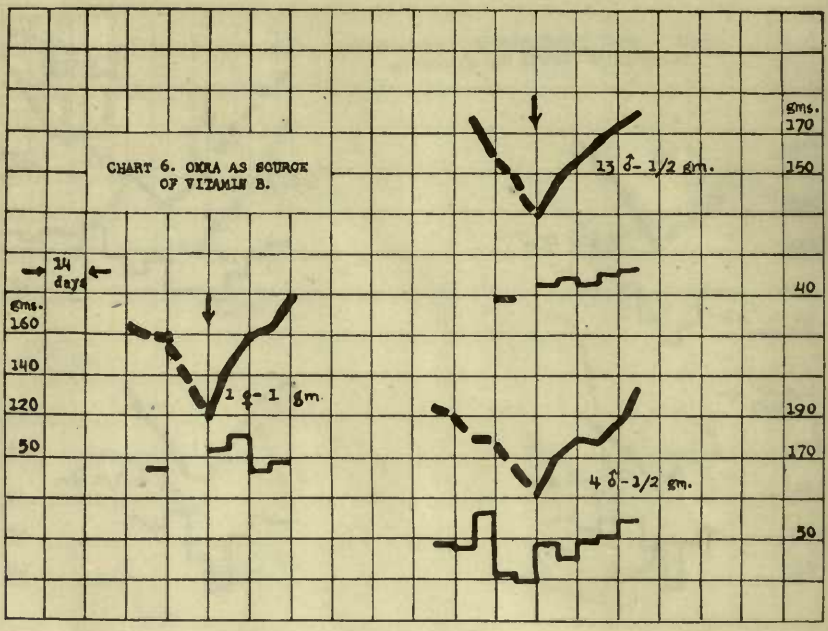


CHART 6. OKRA AS SOURCE OF VITAMIN B.
gms. 170
150
13 ♂- 1/2 gm.
14 days
gms. 160
140
120
50
1 ♀- 1 gm.
40
190
170
4 ♂- 1/2 gm.
50

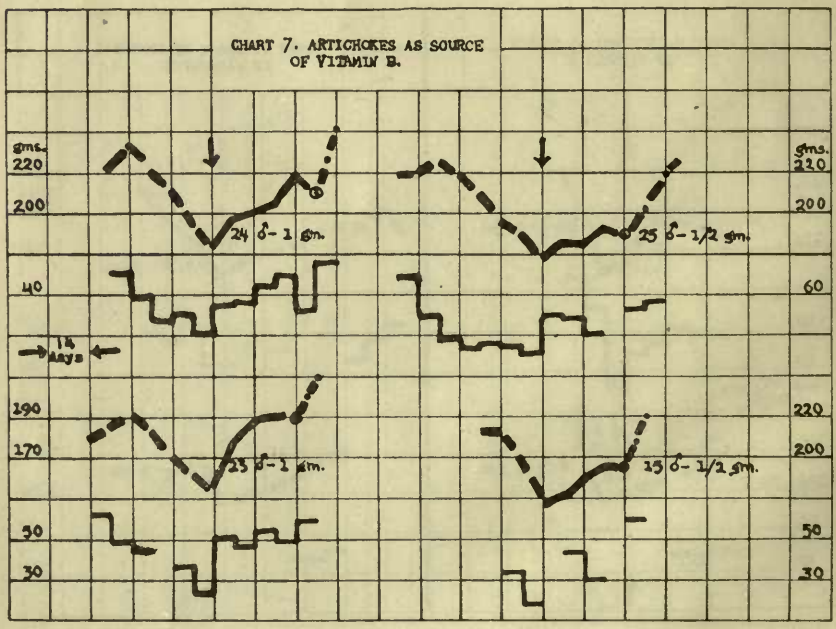


CHART 7. ARTICHOKES AS SOURCE OF VITAMIN B.
gms. 220
200
24 ♂- 1 gm.
25 ♂- 1/2 gm.
40
60
14 days
190
170
23 ♂- 1 gm.
15 ♂- 1/2 gm.
50
30

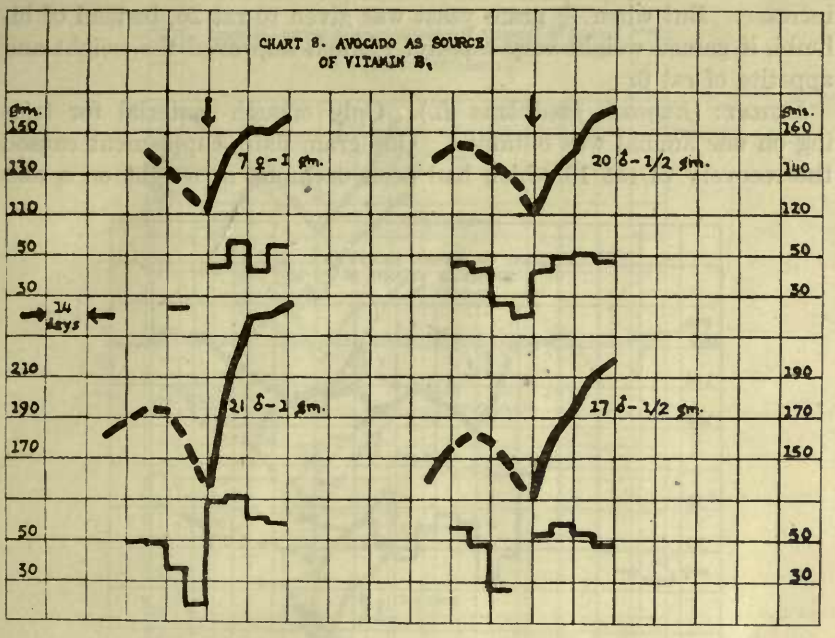


CHART 8. AVOCADO AS SOURCE OF VITAMIN B1
gms.
150
130
110
50
30
7 ♀-1 gm.
20 ♂-1/2 gm.
14 days
210
190
170
50
30
21 ♂-1 gm.
17 ♂-1/2 gm.
gms.
160
140
120
50
30
190
170
150
50
30

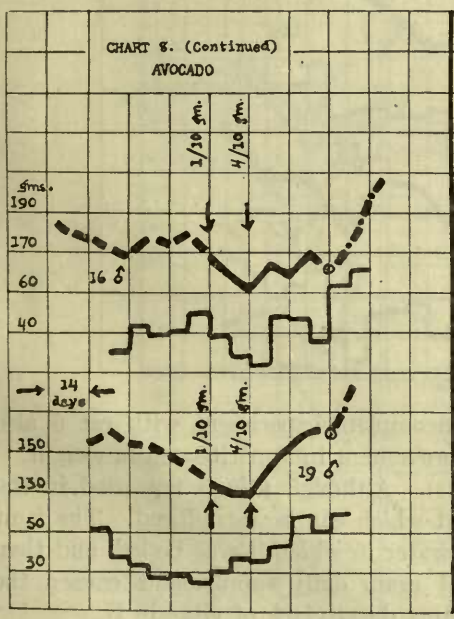


CHART 8. (Continued)
AVOCADO
1/10 gm.
4/10 gm.
gms.
190
170
60
40
16 ♂
14 days
150
130
50
30
19 ♂

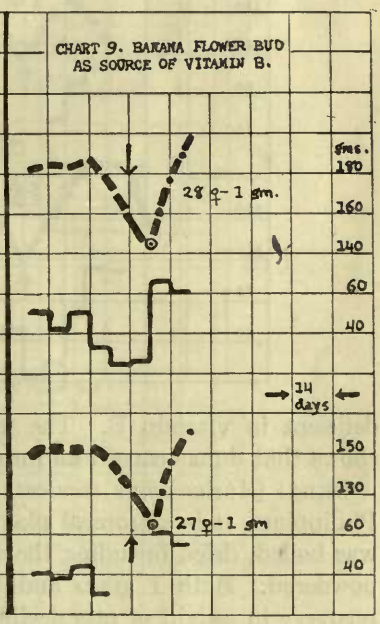
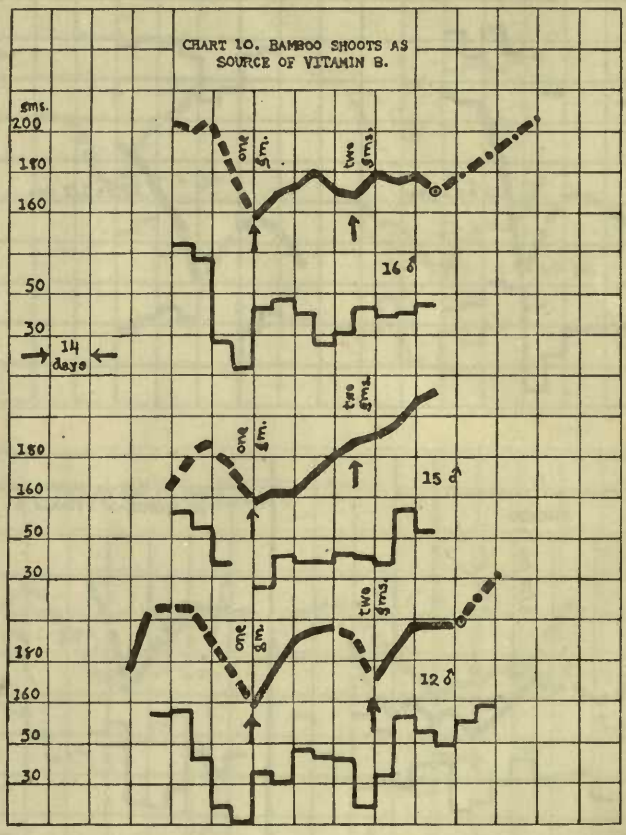


CHART 9. BANANA FLOWER BUD AS SOURCE OF VITAMIN B.
gms.
180
160
140
60
40
28 ♀-1 gm.
14 days
150
130
60
40
27 ♀-1 gm

increase. But when $\frac{4}{10}$ gram yeast was given to rat 26, instead of bilimbi, it gained weight very rapidly. Duhat improved the weight and appetite of rat 6.

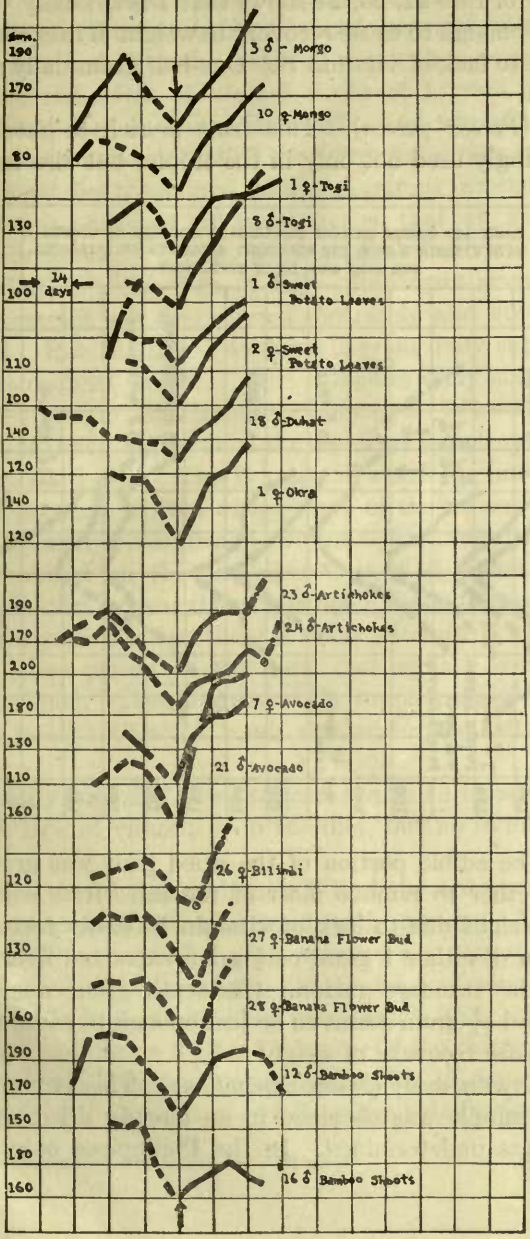
DUHAT: (*Eugenia jambolana L.*). Only enough material for testing on one animal was obtained. One gram daily supplement caused the recovery of rat 18 which had been declining in weight on a diet



deficient in vitamin B. The incomplete experiment with rat 6 also shows that duhat caused an improvement in appetite and in weight.

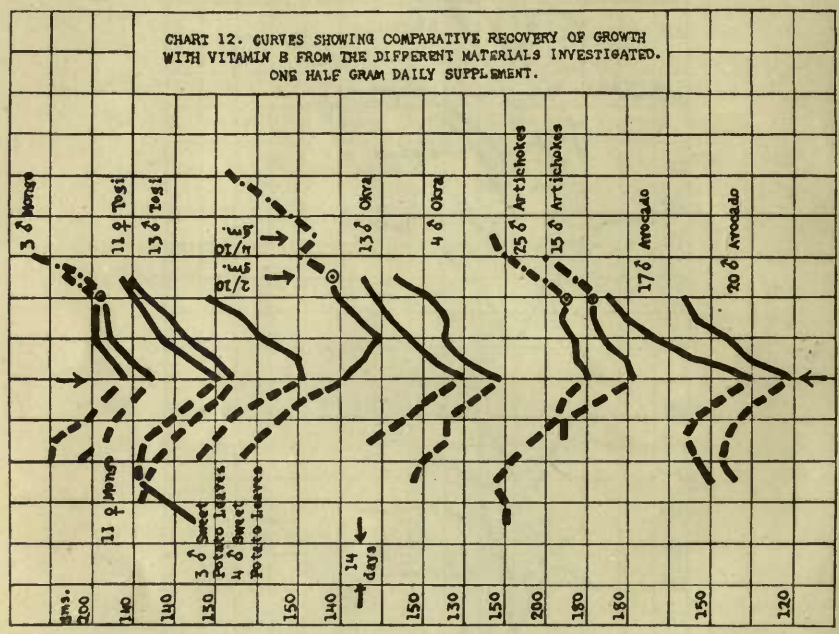
OKRA: (*Abelmoschus esculentus*). Although this is not used in the Philippines, it is a tropical plant which can be introduced. The fruit was boiled, dried including the water in which it was boiled, and then powdered. Both 1 gram and $\frac{1}{2}$ gram daily supplements caused the recovery in weight of rats declining due to lack of vitamin B.

CHART 11. CURVES SHOWING COMPARATIVE RECOVERY OF GROWTH WITH VITAMIN B FROM THE DIFFERENT MATERIALS INVESTIGATED. ONE GRAM DAILY SUPPLEMENT.



ARTICHOKES: (*Cynara scolymus*). Though this has little nutritive value it is eaten as a delicacy. Its use in the Philippines is not known but may be introduced. The edible portion was dried and powdered. The behavior of rats 22, 23, 24 shows that 1 gram daily supplement is probably just enough to cause recovery in weight of rats which had been declining due to lack of vitamin B. One-half gram daily was found to be insufficient.

AVOCADO: (*Persea persea*). This fruit is rich in fat (25), and is being increasingly used not only in the tropics but also in the temper-



ate zones. The edible portion of the dried fruit was ground and extracted with ether to remove most of the fat. Rats which had been declining in weight due to lack of vitamin B, easily recovered on the administration of either 1 gram or $\frac{1}{2}$ gram extracted avocado daily in addition to the standard ration. One-tenth gram was found to be insufficient; and $\frac{4}{10}$ gram seems to be just enough to cause maintenance but not complete recovery of weight.

BANANA FLOWER BUD: (*Musa sapientum*). This is used in making salads. The sample was obtained in an already dried condition and the variety was undetermined. In the Philippines only the buds of

certain varieties are used, because some have bitter taste. Even a 1-gram daily supplement was not sufficient to check the decline in weight of rats which had been taking vitamin B free diet. Similar results were obtained with mice, which could not even be maintained by daily addition of $\frac{1}{2}$ gram of banana flower bud to the basal diet.

BAMBOO SHOOTS: (*Bambusa sp.*). Canned material from Japan was used. The shoots including the water in which they were boiled were dried and powdered. Rat 15 after 5 weeks of 1 gram daily supplement to the basal diet recovered its weight, and when in addition to this supplement alcoholic extract of the powdered shoots was incorporated with the basal diet the animal continued gaining in weight. Enough of the extract was added to the basal diet so that an amount corresponding to approximately 1 gram of the original shoot was eaten by the rat daily in addition to the 1 gram daily supplement given separately. The alcoholic extract was first offered separately also but was refused by the animal. Rat 16 after 5 weeks of 1 gram daily supplement did not recover its original weight. Then a 2-gram daily supplement was given. Neither weight nor appetite improved. Oftentimes the rat was observed to have eaten only the bamboo supplement and very little of the standard food. This is a case in which the limited capacity of the animal prevents it from eating more of the necessary basal diet when the bulky food containing the vitamin was preferred. It finally recovered its weight on the administration of $\frac{4}{10}$ gram yeast daily. Rat 12 did not fully recover its weight after about the same length of time. To determine whether there is really vitamin B in the bamboo shoots, the rat was placed on the basal diet again. Weight and appetite both declined. Then 2-grams daily supplement of bamboo was added to the basal ration. A result similar to that with rat 16 was obtained.

One gram daily was also given to mice which had been declining in weight due to lack of vitamin B in the diet, but no improvement was noticed.

On the assumption that the vitamin B and the antineuritic vitamin are related, an experiment was tried with pigeons. Three pigeons (nos. 1, 2 and 3) were stuffed with polished rice, equal in weight to from $\frac{1}{20}$ to $\frac{1}{12}$ of their body weight, plus 6 grams of powdered bamboo shoots daily. All died of atrophic polyneuritis (13), pigeons 1 and 2 after 18 days, and pigeon 3 after 35 days. Of the three controls without bamboo, pigeon 4 died of polyneuritis after 12 days; pigeon 5 on the 19th day showed a tendency to fall on one side (a sign of polyneu-

ritis) and was cured by the injection of an alcoholic extract from 6 grams of wheat embryo. Control pigeon 6 died of polyneuritis after 31 days. Pigeons 3 and 6 always vomited the food that was stuffed in them except during the 4 or 5 days before their death. It thus appears that bamboo shoots have little vitamin B.

TAMARIND: (*Tamarindus indicus*). The young leaves are used as vegetables and give sour taste to the broth. The rats could not be made to eat the material. Even incorporating the powdered leaves with the basal diet was unsuccessful. Neutralization of the sour taste with sugar was tried but too much sugar was required and thus the material became bulky. The alcoholic extract was also refused by the rats.

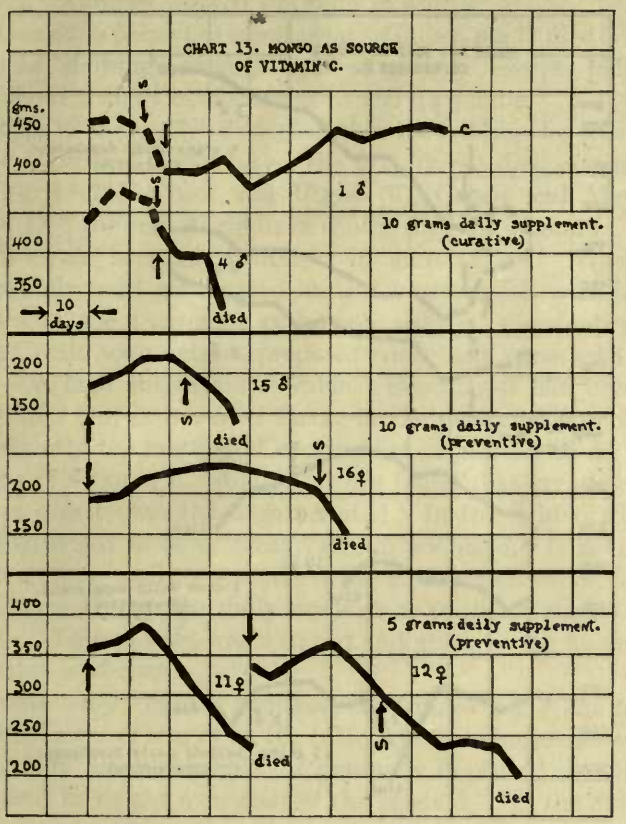
PIGWEED: (*Cycloloma platyphyllum*). This is also used in making stews and gives bitter taste to the broth. Like the tamarind, it was distasteful to the rats.

II. TEST FOR VITAMIN C

Scurvy, like beriberi, is found in the Philippines, being especially common among children under 2 years of age. Poor nutrition is the cause of this. Milk is only within the reach of a few. Cases are common in which mothers who have poor or little milk give the broth of boiled polished rice to the children as a substitute for milk. This milk substitute is of course poor in both vitamins B and C. Since vitamin C is destroyed or diminished in potency under the influence of heat, as in cooking and drying (22), only those materials which promised useful results were tested. The protocols of body weights are given in graphic form in the appendix (charts 13 and 14).

Method: Guinea pigs were used as the experimental animals. Hess and Unger's (23) scorbutic diet of hay, oats, plus 0.5 to 1 cc. of cod liver oil daily and water ad libitum was used as the basal diet in most of the tests. The oil was given by a pipette. At first finely chopped hard boiled egg (yolk plus white) was offered instead of the cod liver oil, but the animals would not eat the former. In the experiment with avocado no use of cod liver oil was made. On the basal ration control guinea pigs (nos. 2, 13 and 14) succumbed to scurvy after 16, 26 and 27 days respectively. In all of the guinea pigs autopsied it was found that the hemorrhages were more severe in those that were not given oil than in those animals that ate the improved diet. At first curative experiments were tried; but it was difficult to make the guinea pigs eat when they were already suffering from scurvy and therefore preventive

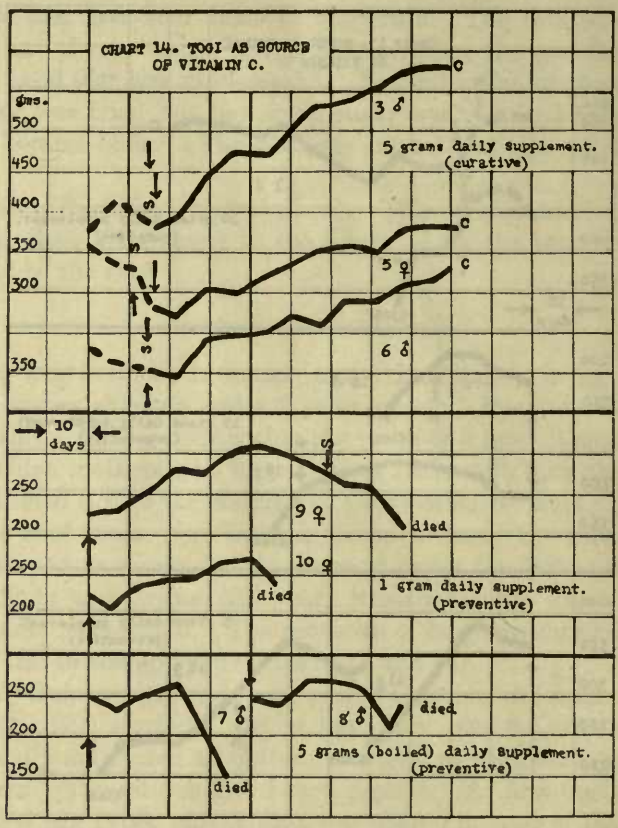
tests were performed. In the curative experiments the animals demonstrated the externals signs of scurvy such as the scorbutic position (22), crying when handled, painful or swollen limbs, and pale gums, before the materials to be tested were given as supplement to the scorbutic diet.



Discussions of the materials used and the feeding experiments. Inasmuch as in every day nutrition the materials to be tested here are never eaten alone, since the amount that an individual can eat in a day is dependent in part on his alimentary capacity, and since, further, our object was to get a comparative estimate of the possible value of the foods as practical sources of vitamin C, a daily supplement of 10 grams to each guinea pig in addition to the basal ration was considered the maximum.

Mongo: (*Phaseolus mongo L.*). In all cases the bean was ground and soaked in water, to make it more palatable, before being offered to the animals.

Ten grams daily curative supplement. Guinea pig 4 began to drag the hind legs after 17 days of scorbutic ration. Mongo was now given



separately as supplement. The decline in weight continued and on the 33rd day it died of scurvy.

Guinea pig 1 showed external symptoms of scurvy on the 14th day of scorbutic diet. When mongo was given, the animal improved in appearance and recovered the original weight. On the 89th day it was chloroformed and autopsy showed little hemorrhage in the right hind leg.

Ten grams daily preventive supplement. Guinea pig 15 never ate all of the mongo. After 25 days, the animal had difficulty in moving the hind legs, and on the 36th day it died of scurvy.

Guinea pig 16 did not eat all of the mongo for the first 2 weeks. On the 57th day the animal began dragging the hind legs, and on the 64th day it died. Autopsy showed the signs of scurvy.

Five grams daily preventive supplement. Guinea pig 11 died on the 40th day without showing external sign of scurvy except pale gums. Autopsy showed slight hemorrhages at the leg joints.

Guinea pig 12 on the 33rd day cried when the left hind leg was touched. Soon an eye became blind and on the 67th day it died of scurvy.

Togi: Fürst (14), Chick and Hume (6), Cohen and Mendel (7), Chick and Delf (5) and others have shown that the vitamin C of dried peas and lentils is much increased in germination. Wiltshire (36) has successfully used germinated haricot beans which were boiled for 10 minutes in the treatment of human scurvy. Gerstenberger (15) found that malt soup extract prepared from malt sprouted in a certain way has high antiscorbutic value. Recently it has been shown that oxidation (10) is the chief factor in the destruction of this vitamin. Evidently the method of cooking has something to do with the destruction of vitamin C. Adkins (1) has found that germinated bean is easier to digest than the ungerminated. In the light of the above findings togi ought to be of great value in nutrition. It is cheap and at the same time easily obtainable. In anticipation of its high content of vitamin C, 5 grams daily supplement to the scorbutic diet was first tried. The togi used was weighed and given to the animals without the outer seed coat.

Five grams daily curative supplement. Guinea pig 3 having developed external signs of scurvy on the 16th day of scorbutic diet was given fresh togi daily as supplement. It gradually improved in appearance and increased in weight over that of the original. On the 89th day it was chloroformed and no sign of scurvy was shown by autopsy.

Guinea pig 5 showed signs of scurvy on the 13th day of scorbutic diet, whereupon it was given fresh togi daily as supplement. It gradually recovered the original weight. On the 91st day it was chloroformed. Autopsy showed nothing abnormal.

Guinea pig 6 on scorbutic diet developed signs of scurvy on the 15th day and was then given fresh togi as supplement. On the 90th day it weighed 100 grams over the initial weight. When autopsied after being chloroformed no sign of scurvy was found.

One gram daily preventive supplement. Guinea pig 9 was given togi as supplement in addition to the scorbutic diet. On the 60th day it began dragging the hind legs, and on the 78th day died of severe scurvy.

Guinea pig 10 was treated the same as guinea pig 9. On the 46th day it died without external sign of scurvy. Slight hemorrhages at the limbs were seen when autopsied.

Five grams boiled (10 minutes) togi daily preventive supplement. Guinea pig 7 died of scurvy after 34 days on the scorbutic diet, plus boiled togi daily. Guinea pig 8 on the same food as guinea pig 7 died of scurvy on the 38th day.

To both animals the water in which the togi was boiled was also offered. Care was taken to boil the togi in the least amount of water possible, and boiling was conducted in a covered vessel as is done in every day cooking.

Avocado: (*Persea persea*). This fruit is eaten raw, and if it could be shown to be high in vitamin C, it would be of great value. Unfortunately the guinea pigs would not eat the avocado; so both the preventive and curative experiments were unsuccessful.

SUMMARY

Several plant foods were tested for their content of vitamins B and C.

Togi, okra and *avocado* were found to be comparatively high in vitamin B. One-half gram of each of them as daily supplement to the standard vitamin B free diet caused the recovery in weight of rats which had been declining because of lack of this accessory food factor.

Mongo, sweet potato leaves and duhat contain enough vitamin so that 1 gram of them as daily supplement caused the recovery in weight of rats which had been declining due to lack of vitamin B.

Artichokes, bilimbi, banana flower bud and bamboo shoots are relatively poor in vitamin B.

The vitamin B in mongo was increased in germination, a fact contrary to the finding of Grijns (19) that the anti-beriberi vitamin is lessened in amount as germination takes place. Mongo is relatively poor in vitamin C.

Togi when fresh is relatively rich in vitamin C; but after it is prepared for culinary use, the vitamin C is destroyed.

The observation of several investigators that vitamin C is increased when peas, lentils and beans are germinated, has been verified in the

case of mongo. Ten grams of mongo as daily supplement to the scorbutic diet failed to protect guinea pigs from scurvy, while 5 grams of fresh togi as supplement to the same scorbutic diet cured 3 guinea pigs of the disease.

I desire to express my hearty thanks to Prof. Lafayette B. Mendel for suggesting this subject to me, for his help in securing the materials investigated, and for advice and criticism during the progress of the work. Part of the expenses was defrayed by a grant from the Russell H. Chittenden Research Fund for Physiological Chemistry.

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Key to tables

x = feeding of source of vitamin B as daily supplement was begun.
y = $\frac{4}{10}$ gram yeast replaced other vitamin supplement.
? = intake of standard diet could not be measured because the animal scattered the food.
The weekly intake of standard diet does not include the vitamin supplement.

Key to charts

S = external sign of scurvy was first detected.
C = animal was chloroformed.
· = $\frac{4}{10}$ gram yeast replaced other vitamin supplement.
---------- = growth on standard diet alone.
———— = growth on standard diet plus vitamin supplement other than yeast.
—·—·—·— = growth on standard diet plus yeast.
The arrow, unless labeled otherwise, indicates the point where the feeding of source of vitamin B or C was begun.
The weekly intake of standard diet is represented in graphic form under each curve of weekly body weight.